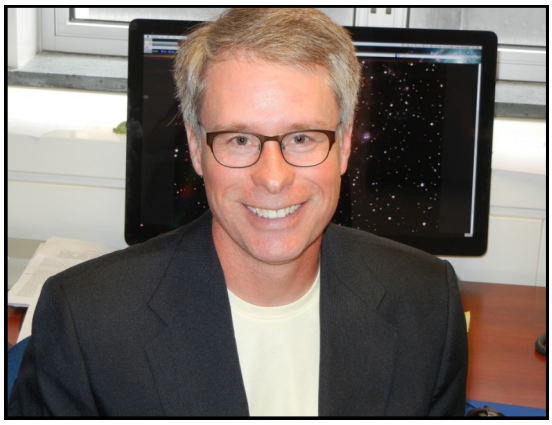
Astronomy News

Case Western Reserve University Department of Astronomy 2013

Stacy McGaugh joins CWRU Astronomy



Professor Stacy McGaugh

In Fall 2012, CWRU Astronomy welcomed in its newest faculty member, Professor **Stacy McGaugh.** Stacy comes to us after many years as a faculty member in the astronomy department at the University of Maryland. He earned his PhD in astronomy from the University of Michigan and held research fellowships at the University of Cambridge, the Carnegie Institution of Washington, and Rutgers University before joining the University of Maryland.

Stacy is an expert in galaxy formation and evolution, cosmology, dark matter, and alternative gravity models. His early work concentrated on the properties of "low surface brightness galaxies," a population of dim, gas-rich, and relatively unevolved galaxies that challenged models for star formation and galaxy evolution. His discovery that these galaxies were gravitationally dominated by their dark matter halos then led him into tests of dark matter and the surprising result that alternative gravity models proved quite effective at explaining their properties. He later discovered the "baryonic Tully-Fisher relationship," which shows that the speed at which spiral galaxies rotate is directly dependent on the amount of normal matter (gas and stars) that they contain; this ranks as one of today's most perplexing challenges for models of galaxy formation and dark matter.

Since his arrival last fall, Stacy has added two new courses to the CWRU Astronomy curriculum. The first, *Perspectives on the Cosmos*, is a SAGES University Seminar, focused on critical thinking about models of the universe from ancient times to the modern day. As a University Seminar, the course is largely discussion-based, with a heavy emphasis on critical thinking, writing, and presentation. This fall, he will be teaching another new course, *Dark Matter*, geared both toward grad students and upper level astronomy and physics undergraduates, which explores observational evidence and theoretical models for dark matter in the universe.

You can learn more about Stacy's research and educational interests at his CWRU Astronomy homepage: astronomy.case.edu/ssm.

INSIDE

Low Surface Brightness Galaxies	2
Research Notes	3
Student Highlights	4-5
Seyfert Fellowship	5
April Fool's Day	6
Frontiers of Astronomy	7
Chair's Space	7
Alumni Updates	8
PAC Trip to Tucson	9
The Burrell Schmidt	10

Case Western Reserve University
Department of Astronomy
10900 Euclid Avenue
Cleveland, OH 44106
Office: 567 Sears Library
Phone: (216) 368-3728
Email: dept@astronomy.case.edu

On the Web:
astronomy.case.edu

On Facebook:
facebook.com/cwruastro

COLLEGE OF ARTS AND SCIENCES
CASE WESTERN RESERVE UNIVERSITY

Low Surface Brightness Galaxies

Low surface brightness galaxies are an enigmatic component of the galaxy menagerie. Their distinguishing characteristic results from a low density of stars. These are spread thin compared to the more familiar members of the Hubble Atlas, such as Andromeda (M31) or the Pinwheel Galaxy (M51).

Morphologically, low surface brightness galaxies are typically late type spiral and irregular galaxies. They are often low luminosity dwarf galaxies, but not always — many examples are comparable to the Milky Way in diameter if not total brightness. Indeed, some of the largest galaxies known are low surface brightness, including the giant Malin 1 with a diameter at least five times that of the Milky Way.

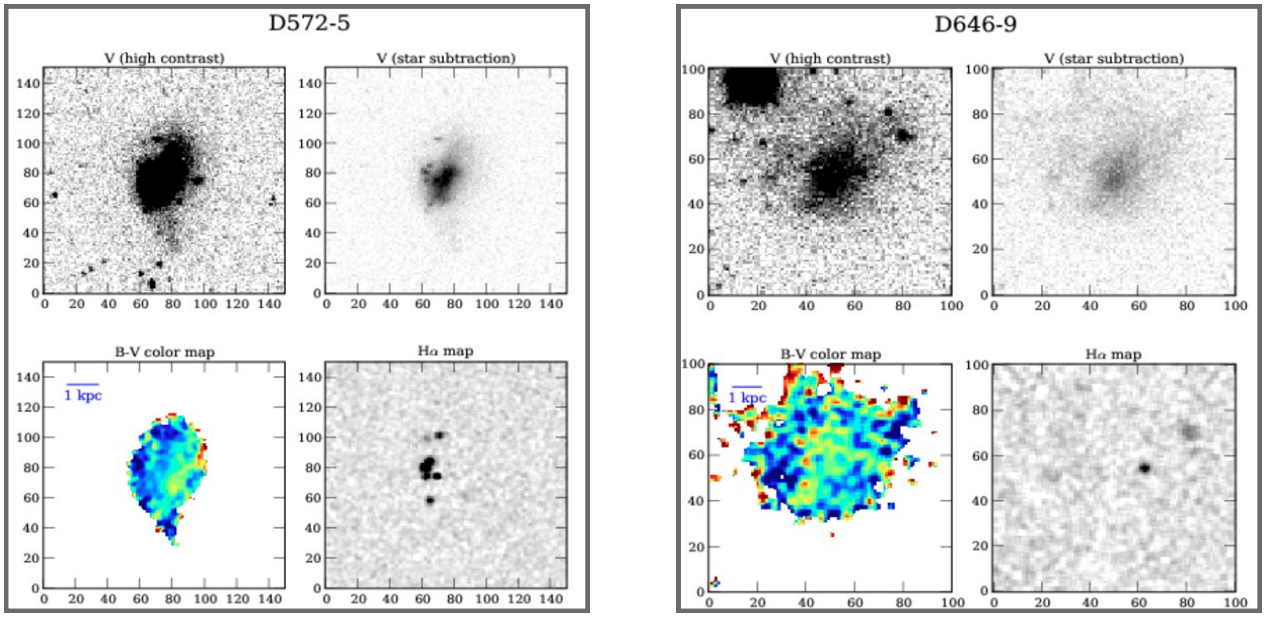
Much of Professor **Stacy McGaugh**'s research focuses on trying to understand the population of low surface brightness galaxies. How many are there? How did they form? Why are their stars spread so thin?

One intriguing observation shows that low surface brightness galaxies can be very blue. It is not unusual to find optical colors consistent with those of late A type stars. This implies a large population of young stars, a puzzle in galaxies with little apparent star formation (see the figure below).

Low surface brightness galaxies are also some of the most gas rich objects in the universe, with gas fractions sometimes exceeding 90 percent. With so much gas, they have plenty of material from which to form stars. However the gas is also spread thin, making it difficult to turn into stars.

A further clue is offered by the low metallicity observed in the galaxies' gas. This quantity should track the evolution of a galaxy — as gas is converted to stars, the stars return metals to the gaseous interstellar medium. The more star formation, the less gas and the more metals.

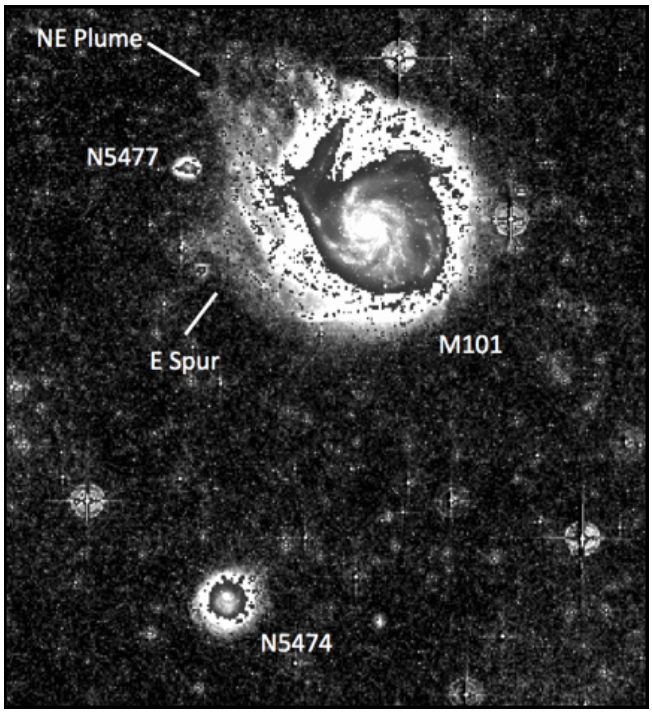
The low metallicities, large gas fractions, and blue colors of low surface brightness galaxies all suggest that they are slowly evolving members of the galactic community. Though slow to form stars, they will continue to have the capacity to do so long after brighter galaxies have run through their current supply of gas. So while these galaxies are dim at present, their future may be bright.



Examples of low surface brightness galaxies D572-5 and D646-9. The top rows show high and low contrast images of these galaxies, which are notoriously hard to spot in sky surveys. The color maps illustrate how very blue these objects can be, while the Hα maps show the location of current star formation: a half dozen distinct HII regions in D572-5, but only a single HII region is D646-9.

Research Notes

The Pinwheel's Outer Disk



Deep image of M101 and its companion galaxies, taken with CWRU Astronomy's Burrell Schmidt telescope.

Using both deep optical imaging from CWRU's Burrell Schmidt telescope and very sensitive mapping of hydrogen gas using the giant Green Bank radio telescope, Professor **Chris Mihos** and his collaborators, including Observatory Manager **Paul Harding** and undergraduate major **Chelsea Spengler** (now at the University of Victoria), have produced the deepest map ever of the faint outskirts of the nearby giant spiral galaxy M101 (The Pinwheel Galaxy). The optical imaging — capable of detecting diffuse starlight a hundred times fainter than the dark night sky — reveals plumes of stars extending out 150,000 light years from the center of M101. The stars in the NE Plume are very blue, suggesting they were formed in a burst of star formation about 300 million years ago, likely during a collision involving one of M101's neighboring companions. The deep radio map shows an even more extended plume of hydrogen gas stretching 300,000 light years beyond the galaxy's southwest edge. Gas falling back into M101 from this extended gaseous plume could be responsible for the strange "high velocity cloud complexes" discovered in the galaxy's disk nearly 25 years ago. In addition, the radio observations led to the discovery of two new companions for M101: a very faint, gas-rich dwarf galaxy and a starless companion containing 10 million solar masses of hydrogen gas. Taken together, these optical and radio datasets suggest that the dynamically active group environment around M101 is leading to the ongoing buildup of gas and stars in M101's outer disk.

The Age of the Milky Way's Halo

An artist's rendition of the Kepler satellite in orbit.

Understanding how our Milky Way galaxy formed continues to be a challenge for astronomers, and one of the key ingredients to solving this puzzle is getting accurate ages of old stars in the Milky Way's halo, relics from the Galaxy's formation era. **Paul Harding** is part of a research team using data from the *Kepler* satellite and ground-based telescopes to measure the ages of these halo stars using a technique called asteroseismology. While *Kepler* is well known for its many discoveries of planets around distant stars, it has also given astronomers a wealth of data on the variability of stars, and has shown that virtually all red giant stars go through non-radial vibrations at very small levels. By studying these stellar vibrations, astronomers can accurately model a star's inner structure (much the way earthquakes tell us about the interior of the Earth) and thereby determine its mass and age with an uncertainty of only ~ 10-15 percent.

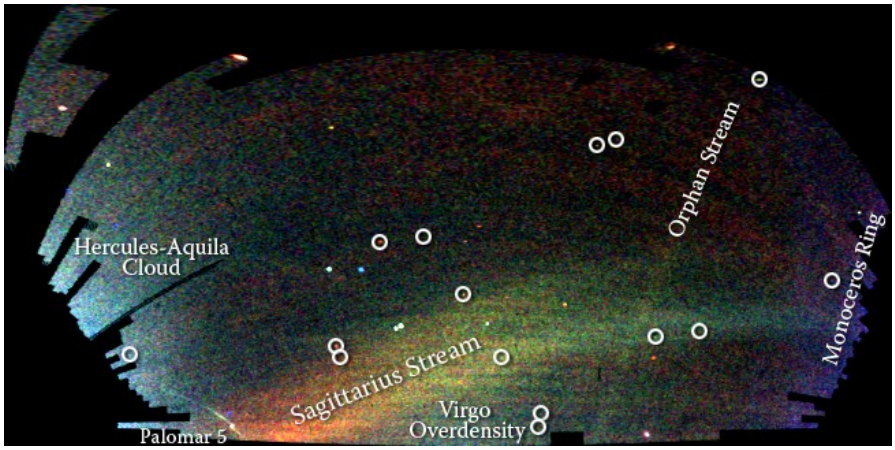
But it turns out finding these rare halo giant stars is tricky, as the much-more-common younger stars in the Milky Way's disk have similar photometric properties as the halo giants; it takes high precision photometry to weed out the disk stars. Working with CWRU graduate student **Tom Reding** and undergraduate **Max Service** (now in graduate school at the University of Hawaii), Harding has been using the Burrell Schmidt to survey the Kepler field at very high photometric precision to find these halo giants and determine their metallicity, a critical input to the asteroseismology study. While the *Kepler* satellite has likely reached the end of its mission, these kinds of analyses on the data it has taken to date should give us valuable new insights into the age and assembly history of our own Milky Way Galaxy.

Student Highlight: Bill Janesh

Since graduating from CWRU in 2011, I've spent the past two years working as a research assistant (and honorary graduate student) here with Professor **Heather Morrison**. I'm also pleased to say that I will be starting a PhD program in astronomy at Indiana University this fall.

But let's talk about my research. I've been working on a project that is a companion to graduate student **Zhibo (Real) Ma**'s thesis work. Astronomers think that the Milky Way was assembled through accretion, meaning that a number of smaller objects came together to form one larger object. This process is still going on today. As small dwarf galaxies merge with the much larger Milky Way, they're torn apart by tidal forces, leaving long streams of stars. This can be seen in the image below--the famous "Field of Streams," which shows streams and other clumps of stars (also known as kinematic substructure) in the Milky Way's halo.

My project uses the largest sample of red giant stars of its kind, assembled by Real, to take the analysis one step further. SEGUE, part of the Sloan Digital Sky Survey, records velocity information as part of its spectroscopic survey of stars. We use this velocity information along with the stars' positions and distances to try to measure how many streams there are nearby the Milky Way. We have found that the amount of kinematic substructure increases both with distance from the center of the Milky Way and with the metallicity (amount of heavy metals) of stars. We've also been able to identify stars that belong to specific streams, particularly from the Sagittarius Dwarf Spheroidal Galaxy (seen in green and red at right). In fact, we've found that a whopping 13 percent of the stars in our sample are part of the Sagittarius stream, one of the largest structures in the Milky Way halo. — **Bill**



The Sloan Digital Sky Survey's "Field of Streams" image, from Belokurov et al (2006).

Graduate Student Highlight: Aaron Watkins

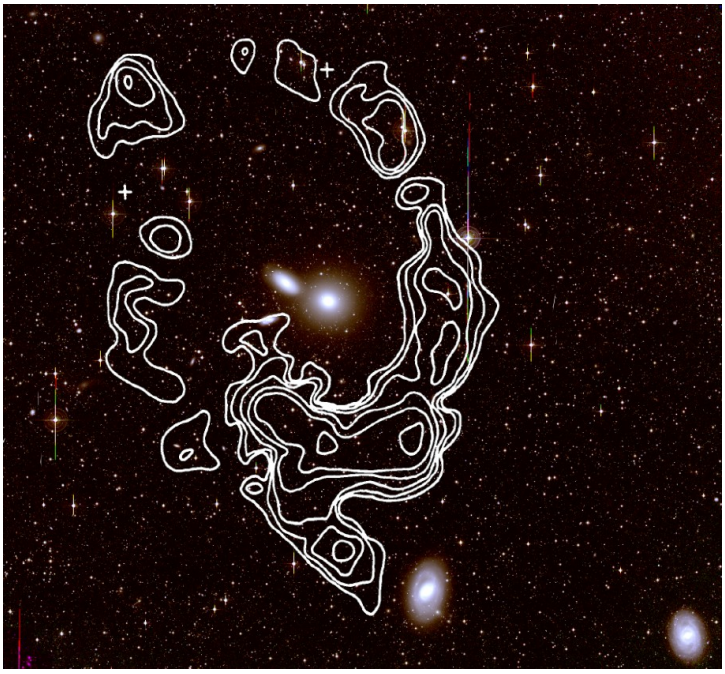
There's a certain thrill to exploratory research. It may not require the same level of constitution as, say, Magellan's circumnavigation of the globe, but the principle is the same: to set out, without knowing what you're going to find, and just take a look around. We astronomers do this with telescopes — the Burrell Schmidt on Kitt Peak, for example, which is what I've been using to explore the outskirts of nearby galaxies.

Now, the inner regions of galaxies are what tend to draw the most interest; they contain spiral arms, dust lanes, giant molecular clouds, bubbles of hydrogen ionized by newborn stars, black holes, and so on. And of course this interest is warranted, but under the current paradigm of galaxy formation, wherein galaxies are built up piece by piece, smaller clumps accreting into larger ones, it stands to reason that there must be activity on galaxies' edges as well. Unless all of the galaxies we see today have for

(Continued on page 5)

(Continued from page 4)

some reason stopped interacting with their environments, objects will still be accreting, falling in, and causing disturbances in those areas most loosely bound to the host and hence most susceptible to agitation. But such areas are hard to see, and so (to continue the metaphor) it remains mostly unexplored territory.



Aaron's deep image of the Leo Group of galaxies, with contours overlaid showing the hydrogen gas in the Leo Ring (from Michel-Dansac et al 2010).

Working with **Chris Mihos** and **Paul Harding** and spending many lonely, cold nights up on Kitt Peak, I've managed to make incredibly deep images of four nearby spiral galaxies and one nearby galaxy group. The work has already drawn some interest; in January, I was awarded a $1,800 Sigma Xi Grant-in-Aid of Research to help fund the observations, and at the end of May, I presented preliminary results for the Leo Group images at the Galactic Gas Supply workshop at the National Radio Astronomy Observatory in Green Bank, W.Va. This group of galaxies has an associated ring of neutral hydrogen gas, the origin of which remains mysterious. Our results, in conjunction with existing optical and ultraviolet data, seem to confirm that dense gas clumps in the ring are currently forming stars — a very nice probe into the chemical composition of the ring, assuming we can get the time to look into that with a bigger telescope. In addition to that, we see evidence of collisions between the galaxies in the form of faint stellar streams not previously detected in any other study. If we put these two things together, we just may be able to resolve the 30-year-old debate about where the ring came from. — **Aaron**

Seyfert Fellowship

Over the past several years, CWRU Astronomy hosted the Carl K. Seyfert Fellowship program, which brought an undergraduate student to Cleveland for the summer to work on cutting-edge research with CWRU astronomers. The fellowship was awarded after a national competition each spring, and past recipients of the fellowship include:

2011: **Hope Miller** (Clarion College)

2010: **Lauren Kahre** (University of Alabama-Huntsville)

2009: **Sam Stoever** (Cornell University)

2008: **Ed Montiel** (University of Arizona)

The fellowship was made possible by a generous contribution from CWRU Astronomy alumnus **Dr. Anthony Wasilewski**, whose doctoral research was based in part on Carl Seyfert's pioneering work on active galaxies.

*I would like to thank the CWRU Astronomy Department for granting me a Seyfert Fellowship. I had a great time and really enjoyed working with **Dr. Idit Zehavi** and **Hong Guo**. I was fortunate enough to work on two projects, both concerning large scale structure of galaxies. I learned about galaxy selection colors while working with Hong and was also able to learn about the Galaxy Zoo Project with Dr. Zehavi. Besides studying astronomy this summer, I also got my first experience with computer programming. This summer gave me a great hands-on opportunity to see how real science is done and has also taught me valuable researching skills. I had a great time with the other students in the department both inside and outside of work. Everyone in the department was so helpful and friendly and got me even more interested in astronomy .*

— Hope Miller, 2011 Seyfert Fellow

April Fool's Day at CWRU Astronomy

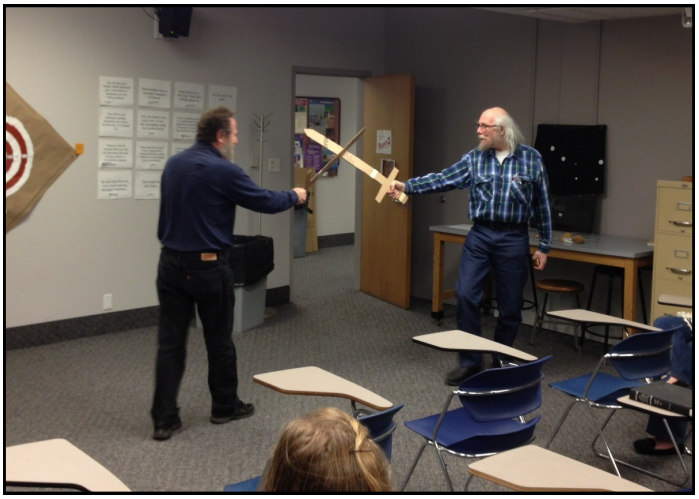
One of our fondest traditions is the annual transformation of the department by our students on April Fool's Day. In past years we've seen the department turned into Australia (everything on the doors and walls was turned upside down), a recreation of *2001: A Space Odyssey* (complete with a giant monolith in the bathroom), and *The Hitchhiker's Guide to the Galaxy* (what was the Infinite Improbability Drive? Why, the departmental coffee machine, of course!).

Here is an assortment of pictures from recent years. In 2011, we became the Star Wars "Rebel Department of Astronomy," complete with the observatory dome on the top of A.W. Smith turned into a giant R2D2 *(your faithful department chair got an earful from the campus safety officer after that one, by the way).* April Fool's 2012 saw the department turned into a giant "Astropoly" game board, where observatories and telescopes were bought and sold using allocations of observing time. Most recently, in 2013, we were thrust back in time hundreds of years and found ourselves as the Medieval Department of Astronomy, featuring such luminaries as Sir Modified Newton, the Duchess of Sloan, and Earle of Grey Case. Who knows what next year will bring?

The campus observatory masquerades as a giant R2D2 on April Fool's Day 2011.

2011 graduating seniors Bill Janesh, Tom Connor, Louis Susco and Elizabeth Palmer tackle the Death Star in the Astronomy classroom.

CWRU Astronomy students show off their 2012 Astropoly board.



Paulileo Paulilei and King Charles battle it out in a swordfight in the 2013 Medieval Department of Astronomy.

Frontiers of Astronomy Lecture Series

Since the 1920's, CWRU Astronomy has sponsored the Frontiers of Astronomy public lecture series. These free talks are presented at the Cleveland Museum of Natural History; the Cleveland Astronomical Society and the Cleveland Museum of Natural History are co-sponsors, along with the support of the Arthur S. Holden, Sr. Endowment.

If you are in the Cleveland area, please join us for these free public lectures — last year we had more than 1,800 people in attendance! See the schedule below and check out our website astronomy.case.edu for more information.

Cleveland Museum of Natural History

Oct 17, 2013	Steve Hauck (CWRU)	Mercury and the MESSENGER Mission
Nov 14, 2013	Risa Wechsler (Stanford)	Building the Cosmos
Dec 12, 2013	Steve Rodney (Johns Hopkins)	Chasing Supernovae in the Early Universe
Mar 6, 2014	Cole Miller (Maryland)	The Mysteries of Black Holes
Apr 17, 2014	Caleb Scharf (Columbia)	The Copernicus Complex

Chair's Space

Professor Chris Mihos

This past year has been an extraordinarily busy one around the department. We've grown in leaps and bounds, adding faculty, bringing in new postdocs, and doubling the size of our graduate program! CWRU astronomers have begun an array of new projects using the Burrell Schmidt, including studies of the chemical abundances of stars in the Milky Way and searches for ghostly "light echoes" around the Crab Nebula that would show us what this millennium-old supernova remnant looked like at the time of explosion. We continue to sponsor science education and outreach in the local community, host the Frontiers of Astronomy lecture series, and give science talks on campus, at local astronomy clubs, and even in neighborhood pubs!

Even with all this activity, there are threatening clouds on the horizon. Federal budget pressure on NASA and the NSF are resulting in cuts to research funding in astronomy. The national observatories we use for research are threatened with reduced availability or outright closure of many of their telescopes. Work on new ground and space-based telescopes is being delayed or cancelled. The individual grant programs that fund faculty research and provide stipends and other support for many of our graduate students are shrinking. The biggest challenge to CWRU Astronomy right now is to sustain the momentum we've built, and continue moving forward against the headwinds of these funding challenges.

Much of our ability to weather this storm comes from our friends and alumni. As just one example, this spring when several of our students applied to summer research programs at national observatories, they found those programs cancelled at the last minute due to federal budget cuts. Fortunately, we were able to support them in summer research here in the department, using funding from gifts to the department. Other examples include our participation in the Sloan Digital Sky Survey project, and our ongoing operation of the Burrell Schmidt telescope, both of which are funded in part through departmental endowments. Smaller contributions support graduate student travel, research equipment, and even an occasional pizza party when our hard working undergraduates stay up all night in the astronomy lab toiling away on homework, research, or the next April Fool's prank!

We welcome and appreciate all your support, and continue to work hard to make the CWRU Astronomy experience a valuable and rewarding one for our students, and for our friends and alumni. **— Chris**

Alumni Updates: What are they up to, where have they gone . . .

John Hibbard (BS 1984) has been working at the National Radio Astronomy Observatory since 1997, first as a postdoc and then as a member of the scientific staff. While originally working on cm wave astronomy, he starting working on the Atacama Large Millimeter/Submillimeter Array (ALMA) project in 2005, helping develop the operations plan for the array and for the North American ALMA Science Center (NAASC), which is based at NRAO headquarters in Charlottesville, Virginia. He was appointed the North American ALMA regional center manager in 2007 and is mainly responsible for the international coordination aspects of the NAASC. The most exciting aspect of this job was the rocky but ultimately successful inaugural observing season for ALMA (2011-2012). Recently, he has been spending half of his time in Chile in the ALMA offices preparing for the renewal of the ALMA operations plan for steady-state operations. He is married with two boys, ages 15 and 18.

Bob Beckley (BS 1968) writes, "After graduating from Case, with a degree in astronomy and a love of computer science, I went to work for IBM on the Orbiting Astronomical Observatory project. Upon arriving at IBM to find the OAO project cancelled, I traveled to Norway to work on a global seismic detection system. My education in physics and mathematics was applied to solve earthly vs. stellar problems. Since that time, I became part of Lockheed Martin, where I have worked on various Department of Defense software contracts for undersea systems, including writing the software for submarine sonar tracking. This is a true life example where your Case Astronomy education can be applied to a variety of professional jobs. I'm an avid bicyclist, covering over 3,000 miles per year."

Comings and Goings

This fall, we welcome two new postdoctoral researchers: **Marcel Pawlowski** (currently at the University of Bonn) and **Federico Lelli** (University of Groningen), both of whom will be working with **Stacy McGaugh** on studies of low surface brightness galaxies and modified gravity models.

We also say goodbye to postdocs **Hong Guo** (now a postdoc at the University of Utah) and **Rachel Kuzio de Naray** (now on faculty at Georgia State University), as well as visiting astronomer **Sergei Andrievsky**, who returns to the Odessa National University after a fruitful semester here at CWRU working with **Earle Luck** studying the chemical abundances of Galactic Cepheids.

Thank you!

CWRU Astronomy gratefully acknowledges **Clint (BS 1969)** and **Claudia Silverman** for their donation of an 8-inch Meade telescope to the department. The telescope is available for our faculty, staff, and students to check out and get away from Cleveland city lights for star gazing on clear nights. During his time on campus, Clint took classes from CWRU Astronomy professor **Peter Pesch**, and observed with the 9.5-inch Warner and Swasey refractor (then at the Taylor Road observatory, now on top of the A.W. Smith building on campus).

CWRU Physics and Astronomy Club visits Tucson!

Visiting CWRU's Burrell Schmidt telescope with Aaron Watkins (far left)

For spring break 2013, the CWRU Physics and Astronomy Club headed to Tucson, Ariz., to visit the University of Arizona and Kitt Peak National Observatory. After staying up late the first night enjoying our hotel's outdoor pool and hot tub (imagine swimming outside in March!), we got up early the next morning to tour a few of the optics and mirror labs at the University of Arizona. The optics labs we visited included state-of-the-art holographic facilities (they could actually send holographic images across the country in a few minutes!), quantum well experimental setups and a lab doing microscopic imaging of bugs. After lunch, we witnessed the construction of mirrors of the Giant Magellan Telescope. Once completed, the telescope will have seven 8.4-meter mirrors, and each mirror takes a couple of years to build. Everyone had a great time seeing all the new technology and engineering feats that are happening at the University of Arizona.

The next day, we visited the Arizona-Sonora Desert Museum before departing for Kitt Peak National Observatory, where we were given a tour of a few of Kitt Peak's 27 telescopes. Although the 100-foot tall McMath-Pierce Solar telescope was impressive (especially because we got to go inside of it!), we were all very excited to have the opportunity to see CWRU Astronomy's own 24-inch Burrell Schmidt telescope. It has been housed at Kitt Peak since 1980, and is used in astronomical research by CWRU faculty and students. We were very lucky that **Aaron Watkins**, a CWRU Astronomy grad student, was doing research at the telescope and had time to show us around.

The CWRU Physics and Astronomy Club gaze at Tucson lights from atop Mt Lemmon.

That evening we drove part way up another astronomical mountain, Mt. Lemmon, to do some observing of our own. Unfortunately, we had a telescope with no mount (thank United for that…) so we were not able to look closely at any objects. But we took some incredible pictures of the clear, dark skies, and had a lot of fun lying on the red rocks pointing out stars and seeing the Milky Way streak across the sky. It was a great ending for our short, but epic, adventure to Tucson.

— **Emilie Dunham**, **Nathan Harmon**, **Wes Peters** and **Sean Linden** (all BS 2014)

We want to hear from you!

Let us know about your job changes, awards, honors and life events. Please email your news and contact information updates to dept@astronomy.case.edu.

CWRU Astronomy's Burrell Schmidt Telescope

In September 2012, astrophotographer **Sean Parker** visited Kitt Peak National Observatory and took several shots at CWRU Astronomy's Warner and Swasey Observatory. In one image, **Paul Harding** stands with the Burrell Schmidt in a fisheye view of the inside of the observatory dome. The second image at the bottom of the page shows the Milky Way stretching high above the observatory dome as a ghostly Paul Harding slips inside.

You can see more of Sean's work at his website www.sean-parker.com and also watch a short YouTube video clip of the Burrell Schmidt working at night at tinyurl.com/burrell-in-motion.

Support the Department of Astronomy

You can contribute to our success by making a gift to the department. Your gift will help us advance our research programs and offer opportunities for our students to excel academically. Please consider returning a gift in the enclosed envelope or give online at giving.case.edu.

COLLEGE OF ARTS AND SCIENCES
CASE WESTERN RESERVE UNIVERSITY

Department of Astronomy
Warner and Swasey Observatory
Case Western Reserve University
10900 Euclid Avenue
Cleveland, Ohio 44106-7215
astronomy.case.edu

Warner and Swasey Observatory , Kitt Peak, Arizona